Consultative Committee for Space Data Systems

RECOMMENDATION FOR SPACE DATA SYSTEMS STANDARDS

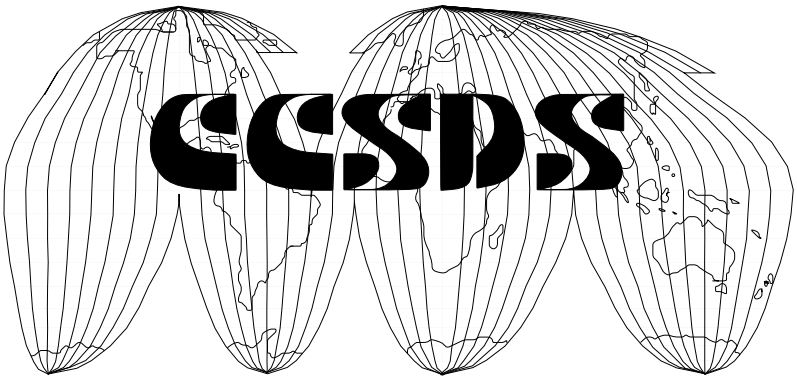
ADVANCED ORBITING SYSTEMS, NETWORKS AND DATA LINKS:

AUDIO, VIDEO, AND STILL-IMAGE COMMUNICATIONS SERVICES

CCSDS 704.0-B-1

BLUE BOOK

May 1994



AUTHORITY

Issue:	Blue Book, Issue 1
Date:	May 1994
Location:	Villafranca, Spain

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CCSDS Secretariat
Program Integration Division (Code OI)
National Aeronautics and Space Administration
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FOREWORD

This document, which is a technical Recommendation prepared by the Consultative Committee for Space Data Systems (CCSDS), is intended for use by participating space Agencies in their development of space data transmission systems that support the transfer of audio, video, and still-image data.

This Recommendation allows the implementing organizations within each Agency to proceed coherently with the development of compatible Standards for the flight and ground systems that are within their cognizance. Agency Standards derived from this Recommendation may implement only a subset of the optional features allowed herein, or may incorporate features not addressed by the Recommendation.

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- United States Geological Survey (USGS)/USA.

DOCUMENT CONTROL

ISSUE	TITLE	DATE	STATUS/ REMARKS
Blue Book, Issue 1	CCSDS 704.0-B-1, Recommendation for Space Data System Standards: Audio, Video and Still-Image Communication Services.	May 1994	Original Issue

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[2] *Advanced Orbiting Systems, Networks and Data Links: Architectural Specification*. Recommendation for Space Data Systems Standards, CCSDS 701.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, November 1992 or later issue.

[3] *Advanced Orbiting Systems, Networks and Data Links: Summary of Concept, Rationale and Performance*. Report Concerning Space Data Systems Standards, CCSDS 700.0-G-3. Green Book. Issue 3. Washington, D.C.: CCSDS, November 1992 or later issue.

[4] *Advanced Orbiting Systems, Networks and Data Links: Audio, Video, and Still-Image Communications Services*. Report Concerning Space Data Systems Standards, CCSDS 704.1-G-3. Green Book. Issue 3. Washington, D.C.: CCSDS, May 1994 or later issue.

[5] *General Aspects of Digital Transmission Systems: Terminal Equipments*. Recommendations G.700–G.772. *CCITT Blue Book* Vol. 3, Fasc. 3.4. Geneva: CCITT, 1989.

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[13] *Information Technology—Digital Compression and Coding of Continuous Tone Still Images*. ISO 10918-1. Geneva: ISO, 1992.

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Note – References for proposed/planned standards are not included.

1 INTRODUCTION

1.1 PURPOSE

The purpose of this Recommendation is to define a set of standardized CCSDS audio, video, and still-image services for cross support between CCSDS Agencies.

The supporting Report (reference [4]) provides implementation guidelines for CCSDS-standardized audio, video, and still-image services for Advanced Orbiting Systems, as defined by CCSDS.

1.2 SCOPE

This Recommendation considers the requirements for accommodating audio, video, and still images in space data systems, and addresses their communication within CCSDS Advanced Orbiting Systems (reference [2]). Such systems may be unpiloted, or they may include a human crew within the space segment.

2 SCOPE OF AUDIO, VIDEO, AND STILL-IMAGE COMMUNICATION SERVICES STANDARDIZATION

2.1 END-TO-END TRANSPORT MODEL

Figure 2-1 presents a model of end-to-end Audio, Video, and Still-Image (A/V/SI) data communication through the CCSDS Principal Network (CPN) of CCSDS Advanced Orbiting Systems (AOS). The model defines three levels of data handling:

– Level 2: Application Services.

  These services provide audio, video, and still images to space mission users.

– Level 1: Communication Interface Services.

  These services map the A/V/SI application service data units into the underlying CPN data transfer protocols.

– Level 0: Data Transfer Services.

  These services communicate the application service data units through the underlying elements of the CPN.

This Recommendation defines standard CCSDS A/V/SI communication services at Levels 1 and 2; the Level-0 services are specified in reference [2]. The Level-1 and -2 services specified herein are intended to facilitate the interchange of information between special-purpose in-space networks and the more general-purpose, commercially supported ground networks. Annexes A, B, C, and D define how the necessary level of compatibility and interoperability may be achieved.

2.2 OVERVIEW OF RECOMMENDED LEVEL-2/1 SERVICES

The recommended Level-2 services for A/V/SI data are presented in Tables 2-1 and 2-2.

The mapping of these Level-2 services into the underlying Level-0 CPN services, via the Level-1 services, is shown in Figure 2-2.

2.2.1 CROSS SUPPORT OF LEVEL-2 SERVICES

All of the Level-2 A/V/SI services are intended for cross support. High-priority services, intended for early implementations of cross support, are indicated in Table 2-1.

2.3 MISSION APPLICATION ENVIRONMENT

For those missions implementing audio data communications in accordance with this Recommendation, the following operational considerations should be observed.

2.3.1 DUPLEX AUDIO COMMUNICATION

All audio services are provided in duplex mode. Half-duplex audio communication involves unidirectional data flow with no concurrent traffic in the return direction. Full-duplex audio communication involves bidirectional data flow, where traffic flows in both directions concurrently.

CCSDS Advanced Orbiting Systems do not support simplex audio communication, where a single channel is alternately shared between forward and return traffic.

2.3.2 END-TO-END DELAY FOR INTERACTIVE AUDIO

For space systems operating in low earth orbit, an interactive mode of full-duplex audio communication is possible where a space link is utilized to conduct a voice dialog.

To support a meaningful, interactive conversation, CCITT establishes a goal for end-to-end round-trip delay to be maintained at less than 600 milliseconds. For space missions (recognizing their inherent long propagation delays), CCSDS recommends that the end-to-end round-trip delay should be optimally maintained at less than 900 milliseconds.

If the end-to-end space mission round-trip delay cannot be maintained at less than 900 milliseconds, then operational procedures will have to be employed to establish rules of conversational dialog between the end users.

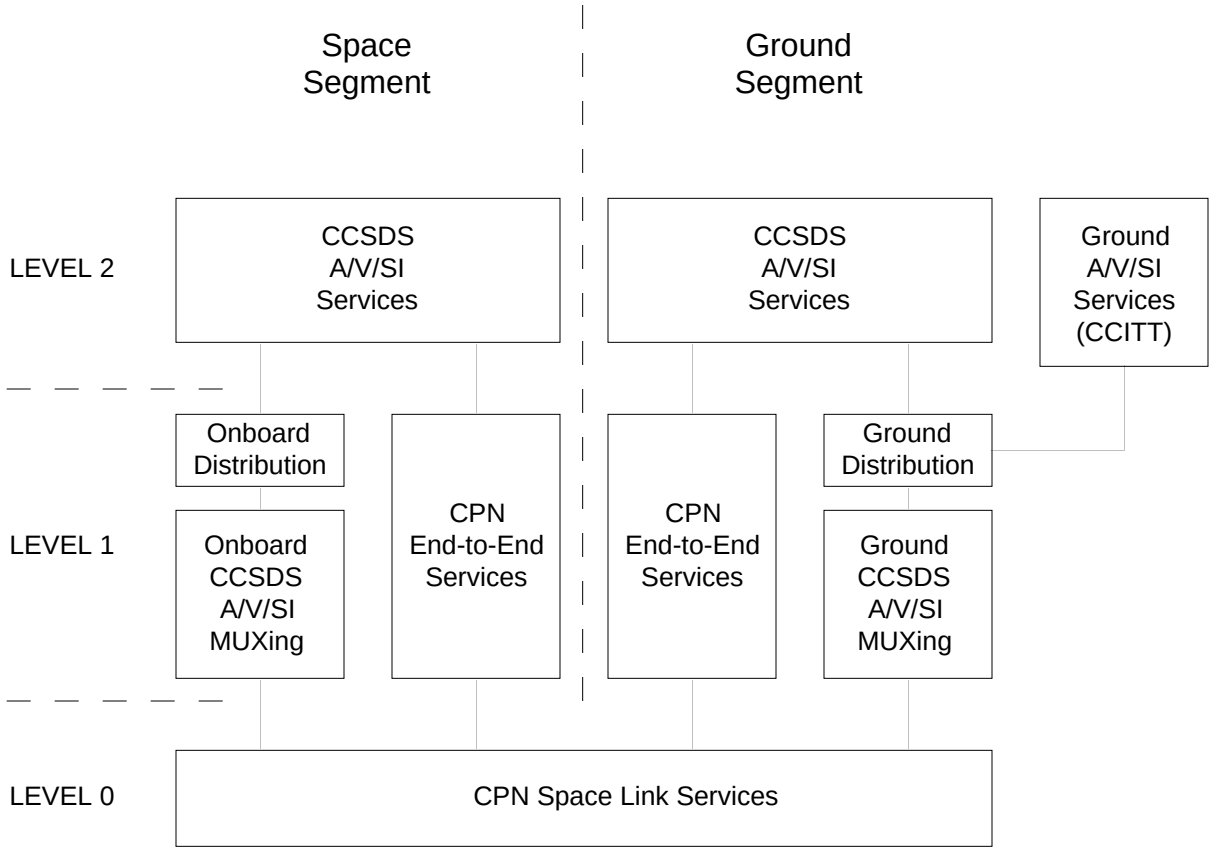

Figure 2-1: Overview of the End-to-End A/V/SI Transport Model

Table 2-1: Overview of the CCSDS A/V/SI Communication Services: Applications and Quality

SERVICE CATEGORY	APPLICATIONS	QUALITY
A4 Hi-fi Audio	• Entertainment • Recreation	≤ 15 kHz (stereo)
A3 Enhanced Audio[1]	• Interviews • Media Dissemination	≤ 7 kHz
A2 Operational Audio[1]	• Crew conversation	≤ 3.4 kHz
A1 Low Rate Audio	• Crew conversation (min channel capacity)	≤ 3.4 kHz
V4 High Resolution Video	• Critical Operations • Critical Payloads • Advanced Media Dissemination	1920∗1152/1080 pels; 25/29.97 Hz; subject to change by CCIR
V3 Broadcast Resolution Video[1]	• Interviews • Media Dissemination • Operations/Payloads	720∗576/483 pels; min. 4:2:2 encoding (studio quality); 25/29.97 Hz
V2 Moderate Resolution Video[1]	• Normal Video Teleconf. Communication	352∗288 pels; 29.97/14.99, 25/12.5 Hz
V1 Low Resolution Video	• Visual communication • Simple Video Equipment	176∗144 pels; ≤ 5 Hz
I3 Still-Image Mode-3[1]	• Visual and computer-aided exploitation of experiment images	variable spatial resolution; 8 bit/pel
I2 Still-Image Mode-2[1]	• Visual and computer-aided exploitation of experiment images	variable spatial resolution; up to 16 bit/pel
I1 Still-Image Mode-1	• Visual and computer-aided exploitation of experiment images	full spatial and radiometric resolution

[1] Service identified for early cross support.

Table 2-2: Overview of the CCSDS A/V/SI Communication Services: Data Rates and Standards

SERVICE CATEGORY	DATA RATES	STANDARDS ADOPTED BY CCSDS
A4 Hi-fi Audio	384/338 kbps 2∗338 kbps (uncomp.)	CCITT Rec.J41
A3 Enhanced Audio[1]	169/196 kbps (uncomp.) 48 kbps (comp.)	CCITT Rec.J41/42 CCITT Rec.G722
A2 Operational Audio[1]	64 kbps (uncomp.) 32 kbps (comp.) 16 kbps (comp.)	CCITT Rec.G711 CCITT Rec.G721 CCITT Rec.G728
A1 Low Rate Audio	2.4 kbps (comp.) 4.8 kbps (comp.)	FED-STD-1015[2] FED-STD-1016[2]
V4 High Resolution Video	0.9–1.2 Gbps[3] (uncomp.) 135–155 Mbps (comp.) ≤ 90 Mbps (comp.)	CCIR 709 CMTT (proposed) CMTT (proposed) MPEG3 (planned for 1994)
V3 Broadcast Resolution Video[1]	216 Mbps (uncomp.) 30–45 Mbps (comp.) ≤ 10 Mbps (comp.)	CCIR 601 AD/CMTT ISO/MPEG2 (proposed)
V2 Moderate Resolution Video[1]	384–2048 kbps (comp.) (p∗64 kbps)	CCITT Rec.H.261 spatial CIF-Format
V1 Low Resolution Video	≤ 1544 kbps (uncomp.)	spatial QCIF-Format
I3 Still-Image Mode-3[1]	depends on image rate, resolution, entropy comp. ratio ≥ 3	ISO/IEC CD 10918-1 (JPEG, Baseline)
I2 Still-Image Mode-2[1]	depends on image rate, resolution, entropy comp. ratio < 3	ISO/IEC CD 10918-1 (JPEG, lossless coding)
I1 Still-Image Mode-1	depends on image rate and resolution	no compression no standard necessary

1 Service identified for early cross support.

2 The FED standard will be replaced by an equivalent CCITT standard when available.

3 Today 1.2 Gbps for tracking systems is not available for uncompressed real-time data of high-resolution video service. When it becomes available, this service can be used.

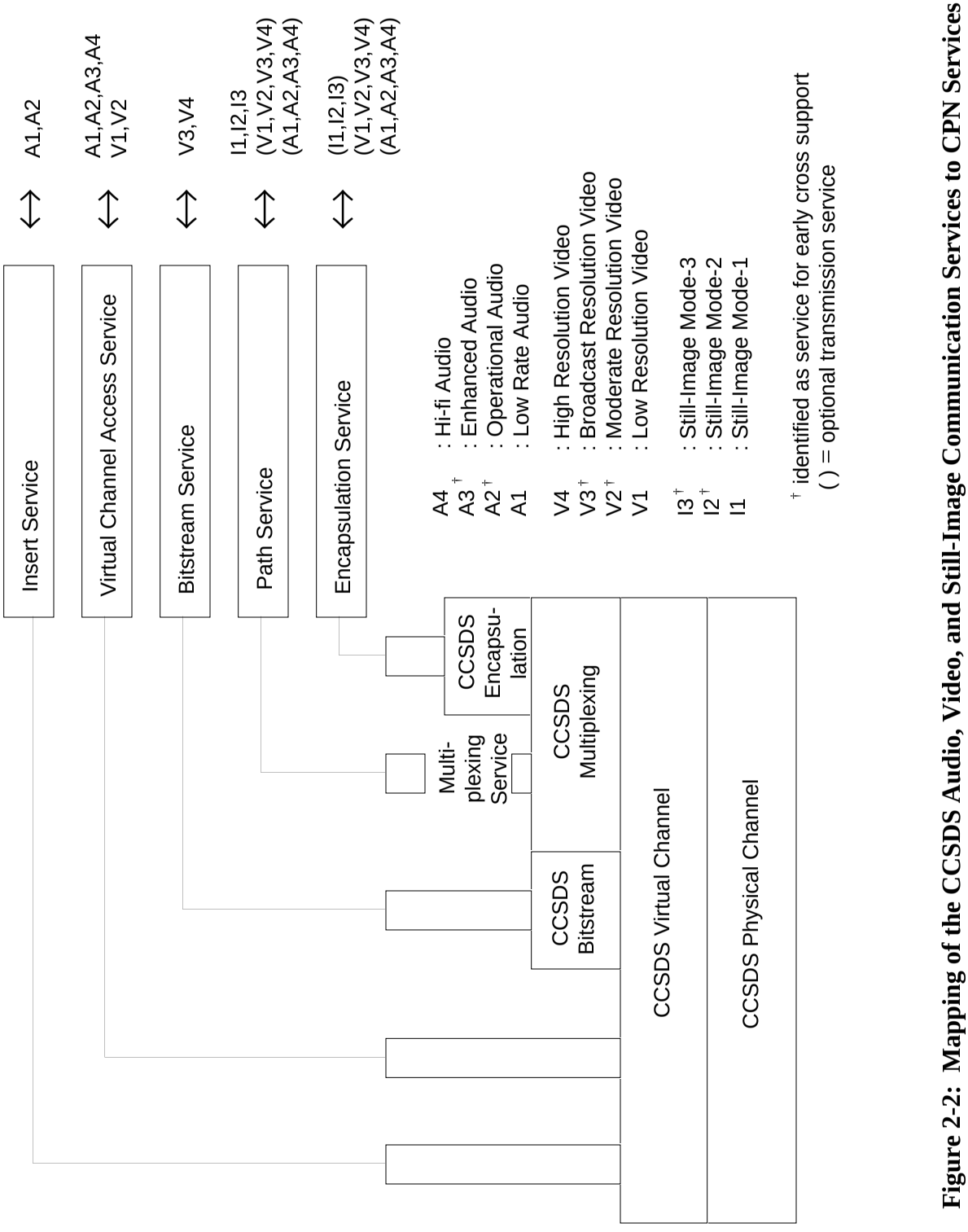

Figure 2-2: Mapping of the CCSDS Audio, Video, and Still-Image Communication Services to CPN Services

3 AUDIO SERVICES AND MULTIPLEXING SPECIFICATIONS

If more than one audio channel shares a CCSDS Virtual Channel (VC), then Level-1 audio communication interface services must be provided to "multiplex" the audio channels that occupy a particular VC.

3.1 AUDIO SERVICES AND APPLICATIONS

Table 3-1 gives a brief survey of the potential audio services in the space environment and the related applications and operational aspects.

Table 3-1: List of Audio Services and Applications

AUDIO SERVICE	APPLICATION	OPERATIONAL ASPECTS
A4 Hi-fi Audio	• Entertainment • Recreation	• unidirectional link • space ↔ ground • during scheduled phases or on demand
A3 Enhanced Audio[1]	• Information or Interviews in broadcast quality • Media Dissemination	• bidirectional or unidirectional link • space ↔ ground • on demand or during scheduled phases (information or interviews with improved intelligibility)
A2 Operational Audio[1]	• crew conversation • Information exchange on mission-critical activities[2] • Instruction and support for payload and experiment control	• bidirectional link • space ↔ ground or space ↔ space • during scheduled phases (operations and payload), or on demand, e.g., during flight maneuvers • adaptable to minimum signal delay
A1 Low Rate Audio	• Routine discussion and information exchange on a low data rate transmission link	• bidirectional or unidirectional link • space ↔ ground or space ↔ space • continuous during the mission

[1] Service identified for early cross support.

[2] The main performance characteristics of audio services for "critical activities" are: a minimal end-to-end signal delay and a defined audio signal quality level.

3.2 AUDIO SERVICE PERFORMANCE

Table 3-2 gives definitions of the currently envisaged audio services provided for space applications (transmitted by CPN) with references to CCITT recommendations or other standards for audio signal coding.

Table 3-2: Audio Service Definitions

AUDIO SERVICE	ANALOG BANDWIDTH	DATA RATE ALLOCATION[1]	PCM CODING
A4 Hi-fi audio	≤ 15 kHz (stereo)	384/338 kbps 2*338 kbps (all uncompressed)	10–11 bit/32kHz PCM + error protection bits in reference to CCITT Rec. J.41
A3 Enhanced audio[2]	≤ 7 kHz	169/196 kbps (uncomp.) 48 kbps (comp.)	10–11 bit/16 kHz PCM + error protection in reference to CCITT Rec. J.41/J.42 SB-ADPCM in reference to CCITT Rec. G.722
A2 Opera-tional audio[2]	≤ 3.4 kHz	64 kbps (uncomp.) 32 kbps (comp.) 16 kbps (comp.)	8-bit/8 kHz PCM A-law in reference to CCITT Rec. G.711 compression in reference to CCITT Rec. G.721 compression in reference to CCITT Rec. G.728
A1 Low rate audio	≤ 3.4 kHz	2.4 kbps (comp.) 4.8 kbps (comp.)	FED-STD-1015 (LPC-10)[3] FED-STD-1016 (CELP)[3]

1 Data rate allocation in one direction, point to point, 1 audio channel.
2 Service identified for early cross support.
3 The FED standards will be replaced by equivalent CCITT standards when available.

End-to-end round-trip delay, which is directly dependent upon the link data rate, shall be optimally maintained under 900 milliseconds. CCITT goals for link round-trip delay are set to be 600 milliseconds for a meaningful interactive conversation, but physical limits may require changes in operational constraints. End-to-end round-trip delay is here defined only for one geostationary hop.

Synchronization of audio services that accompany video services shall be maintained within the tolerances of 25 milliseconds leading video to 40 milliseconds lagging video (ANSI/EIA/TIA RS-250-C-1989).

End-to-end round-trip delay is here defined only for one geostationary hop.

3.3 AUDIO SERVICE MULTIPLEXING

Annex C.1.1 contains the specification of recommended audio multiplexing mechanisms.

3.3.1 Audio Data Block

The audio channel data might be a non-octet-aligned data stream (e.g., in case of audio data compression or in case of transmitting auxiliary data). A non-octet-aligned data stream shall be artificially aligned into an octet structure to enable normal handling of the data stream within the CPN.

The Audio Data Block (ADB) is a fixed-length data structure containing a sequence of "p" audio data octets out of one audio channel. The value of "p" has a considerable influence on the end-to-end audio signal delay.

The value of "p" and the relation between the ADB and the audio channel number (or user) is conveyed by management.

3.3.2 Audio Data Field

The Audio Data Field (ADF) is a fixed-length data structure consisting of "n" ADBs, where "n" is identical with the number of multiplexed audio channels which share the VC (n=1, 2, 3, . . .). The "n" ADBs are arranged in sequence within the ADF.

The value of "n" is conveyed by management.

3.3.3 Audio Data Package

The Audio Data Package (ADP) is a fixed-length data structure consisting of "m" successive ADFs. ADPs with m > 1 are optional and should be used only in special cases, e.g., in the case of low data rate links where the grade-3 CPN Insert service (no Reed-Solomon coding) is used for audio data transmission. The case m = 1 means ADP = ADF. In general, $m*n*p$ has to be smaller than or equal to the Service Data Unit (SDU) size of the applied CPN service. The "m" ADFs are arranged in sequence within the ADP.

If $m*n*p$ is smaller than the size of the SDU, fill bits have to be provided by the service user. The complete SDU containing audio data and eventually fill bits is presented to the appropriate CPN service.

The value of "m" is conveyed by management.

3.3.4 Recommended Audio Service Data Sizes

Table 3-3 provides a brief list of the recommended audio service data sizes. The audio services are defined in terms of: (a) multiplexing parameters (p; n; m), (b) CPN service type, and (c) CPN Grade of Service. Only the normal case of m = 1, which means ADP = ADF, is considered here.

3.4 OPTIONAL PACKETIZED AUDIO DATA TRANSMISSION VIA PATH AND ENCAPSULATION SERVICE

A short description of an optional audio data transmission via Path and Encapsulation service is given in Annex C, Part C.2.

Table 3-3: Recommended Audio Service Data Sizes

AUDIO SERVICE	RECOMMENDED PARAMETER p, n, AND m (SIZE OF ADB/ADF/ADP)	CPN SERVICE RECOMMENDED	GRADE OF CPN SERVICE
A4 Hi-fi audio	if stereo: 2 Audio channels necessary m = 1; n = 2; p ≤ VCA_SDU-size/2 if mono: m = 1; n = 1; p ≤ VCA_SDU-size	VC Access (VCA) service	grade 2 or grade 3[1]
A3 Enhanced audio[2]	p ≤ VCA_SDU-size m = 1; n ≤ VCA_SDU-size/p	VCA service	grade 2 or grade 3[1]

A2
Operational audio[2]
	m = 1; n ≤ VCA_SDU-size/p
	
	if uncompressed G.711:
	p ≤ 400–1200 octets [3]
	
	if compressed G.728:
	p ≤ 100–300 octets[3]
	
	if compressed G.721:
	p ≤ 200–600 octets[3]
		VCA service	grade 2
			or
			grade 3[1]

	if n > 1: p = 1 octet; m = IN_SDU-size/n if n = 1: p = IN_SDU; m = 1	Insert service[4]	
A1 Low rate audio	if 4.8 kbps audio rate p ≤ 90 octets[3]; m = 1; n ≤ VCA_SDU-size/p	VCA service	grade 2 or grade 3[1]
	if 4.8 kbps audio rate if n > 1: p = 1 octet; m = IN_SDU-size/p if n = 1: p ≤ IN_SDU-size; m = 1	Insert service[4]	

1 In reference to data reliability requirements.

2 Service identified for early cross support.

3 Maximum number of octets per ADB, “p” depends on the desired audio signal delay.

4 The Insert service is preferred only when the data rate over the physical channel is limited to 10 Mbps (reference [3]); it may be envisaged when there are very few audio channels and low latency is a high priority requirement.

4 VIDEO SERVICES AND MULTIPLEXING SPECIFICATIONS

If more than one video channel shares a CCSDS VC, then Level-1 video communication interface services must be provided to "multiplex" the video channels that occupy a particular VC.

4.1 VIDEO SERVICES AND APPLICATIONS

Table 4-1 gives a brief survey of the potential video services in the space environment and the related applications and operational aspects.

Table 4-1: List of Video Services and Applications

VIDEO SERVICE[1]	APPLICATION	OPERATIONAL ASPECTS
V4 High Resolution Video	• Critical Operations/Critical Payloads[2] • Advanced Media Dissemination	• unidirectional • space ↔ ground • during scheduled phases or on demand • may be synchronized with audio data
V3 Broadcast Resolution Video[3]	• Visual communication (Information or Interviews) in broadcast quality • Monitoring of experiments (including Telescience operation)	• unidirectional link • space ↔ ground • on demand or during scheduled phases • may be synchronized with audio data
V2 Moderate Resolution Video[3]	• Visual communication during routine work to support and provide mutual understanding of the current situation or operational events • Crew support for payload control • Monitoring of experiments (including Telescience operation)	• unidirectional or bidirectional link • space ↔ ground, space ↔ space • may be synchronized with audio data • service required to support decisions • continuous during the mission • adaptable to minimum signal delay
V1 Low Resolution Video	• Visual communication during routine work to support and provide mutual understanding of the current situation or operational events • Crew support for payload control • low mass and low power alternative for visual use	• unidirectional or bidirectional link • space ↔ ground, space ↔ space • service required in case of strong onboard power and mass restrictions or in case of a low transmission error sensitivity requirement of the video signal • continuous during the mission • may be synchronized with audio data

1 The current CCSDS Path service does not guarantee either completeness or in-sequence data delivery without the provision of additional (upper layer) services by the service provider. Where completeness and/or sequential delivery is a requirement, the user should identify this to the Path service provider and request a corresponding level of service. Note that the CCSDS packet (see reference [2]) provides a sequence count field which may be used by the video application to assist in achieving re-sequencing.

2 The main performance characteristics of video services for "critical operations/payloads" are: true color representation and high resolution.

3 Service identified for early cross support.

4.2 VIDEO SERVICE PERFORMANCE

Table 4-2 gives a definition of the currently envisaged video services provided for space applications (transmitted by the CPN) and the references to ground video standards and recommendations.

End-to-end round-trip delay, which is directly dependent upon the link data rate, shall be optimally maintained under 900 milliseconds, but physical limits may require changes in operational constraints.

Synchronization of audio services that accompany video services shall be maintained within the tolerances of 25 milliseconds leading video to 40 milliseconds lagging video (ANSI/EIA/TIA RS-250-C-1989).

End-to-end round-trip delay is here defined only for one geostationary hop.

Table 4-2: Video Service Definitions

VIDEO SERVICE	SPATIAL, TEMPORAL AND RADIOMETRIC RESOLUTION	DATA RATE ALLOCATION[1]	COMPRESSION STANDARDS
V4 High Resolution Video	1920∗1152/1080 pels 25/29.97 Hz full-image sequence 8 bit/pel/component is a subject to change by CCIR	0.9–1.2 Gbps[2] (uncomp.) 135–155 Mbps (comp.) < 90 Mbps (comp.)	CCIR 709 CMTT proposed CMTT proposed MPEG3 (planned for 1994)
V3 Broadcast Resolution Video[3]	720∗576/483 pels minimum 4:2:2 sampling CCIR 601(studio qual.) 25/29.97 Hz full-image sequence 8 bit/pel/component	216 Mbps (uncomp.) 30–45 Mbps (comp.)[4] < 10 Mbps (comp.)[5]	CCIR 601 AD/CMTT[6] ISO/MPEG2 proposed

1 Data rate allocation in one direction, point to point, 1 video channel.

2 Today 1.2 Gbps for tracking systems is not available for uncompressed real-time data of high-resolution video service. When it becomes available this service can be used.

3 Service identified for early cross support.

4 30–45 Mbps video codec is related to the Draft New Report AD/CMTT; CMTT (Commission Mixte CCITT-CCIR pour les Transmissions Televisuelles et Sonores) is a joint CCITT-CCIR Commission for transmission of television and sound. Information on practical coding systems for the digital transmission of component-coded television signals is given in:
CCIR, Draft New Report AD/CMTT on the digital transmission of component-coded television signals at 30–34 Mbps and 45 Mbps, CCIR-Document(1986–90) CMTT/116+Corr.1.
AD/CMTT algorithm will be published as CCIR 723 recommendation.

5 < 10 Mbps video codec is related to the “Preparatory Draft Proposal Package Description for MPEG Phase 2” (May 17, 1991).

6 AD/CMTT specification provides video data with accompanying audio data.

Table 4-2: Video Service Definitions (continued)

VIDEO SERVICE	SPATIAL, TEMPORAL AND RADIOMETRIC RESOLUTION	DATA RATE ALLOCATION[1]	COMPRESSION STANDARDS
V2 Moderate Resolution Video[2]	352∗288 pels for Y 176∗144 pels Cr,Cb 25/29.97 Hz 12.5/14.99 Hz full-image sequence 8 bit/pel/component	384–2048 kbps (comp.) (p∗64)[3]	CCITT Rec. H.261[4] spatial CIF-Format
V1 Low Resolution Video	176∗144 pels for Y 88∗72 pels Cr,Cb ≤ 5 Hz full-image sequence 8 bit/pel/component	≤ 1544 kbps (uncomp.)	no compression spatial QCIF-Format

1 Data rate allocation in one direction, point to point, 1 video channel.

2 Service identified for early cross support.

3 The data rate allocation of a coder equal to CCITT Rec. H.261 video coding and compression ranges in steps of 64 kbps up to 2048 kbps (p∗64 kbps, p=1...32). Preferred data rates are 384 kbps, 1536 kbps, and 1920 kbps (including space for CCITT H.221 framing data) if only video data has to be transmitted. If audio and video data in parallel are transmitted via a video channel, the preferred data rate for video only (without H.221 framing data) is either 320 kbps (adapted to one H0-channel), 312 kbps (adapted for audio/video data transmission via 6 B-channels), 1472 kbps (adapted to one H11-channel), or 1856 kbps (adapted to one H12-channel). The additional audio data + H.221 framing data takes 64 kbps. The visual performance of the H.261 coder depends on the output data rate. A moderate motion rendition can be achieved with 384 kbps as output data rate; a good motion rendition is given with an output data rate greater than or equal to 1536 kbps. Motion rendition means here the spatial and radiometric reconstruction quality of moving objects in a video sequence with a fixed image frequency.

4 It has been determined that the CCITT recommendations, H.221 for audio/video synchronization and H.242 for signaling, be used for this audio/video service.

4.3 VIDEO SERVICE MULTIPLEXING

Annex C.1.2 contains the specification of recommended video multiplexing mechanisms.

4.3.1 Video Data Block

The video source/output data might be a non-octet-aligned data stream, as in the case of video data compression, in which a variable-length Huffmann-coded data stream will be delivered. A non-octet-aligned data stream shall be artificially aligned into an octet structure to enable normal handling of the data stream within the CPN.

The Video Data Block (VDB) is a fixed-length data structure containing a sequence of “p” video data octets out of one video channel. The value of “p” has a considerable influence on the end-to-end video signal delay.

The value of “p” and the relation between the VDB and the video channel number (or user) is conveyed by management.

4.3.2 Video Data Field

The Video Data Field (VDF) is a fixed-length data structure consisting of "n" VDBs, where "n" is identical with the number of multiplexed video channels that share the VC (n = 1, 2, 3, . . .). In general, n∗p has to be smaller than or equal to the Service Data Unit (SDU) size of the applied CPN service. The "n" VDBs are arranged in sequence within the VDF.

If n∗p is smaller than the size of the SDU, fill bits have to be provided by the service user. The complete SDU containing video data and eventually fill bits is presented to the appropriate CPN service.

The value of "n" is conveyed by management.

4.3.3 Recommended Video Service Data Sizes

Table 4-3 provides a brief list of the recommended video service data sizes. The video services are defined in terms of: (a) the multiplexing parameters (p; n; q), (b) the CPN service type and (c) the CPN Grade of Service.

4.4 OPTIONAL PACKETIZED VIDEO DATA TRANSMISSION VIA PATH AND ENCAPSULATION SERVICE

A short description of an optional video data transmission via Path and Encapsulation Service is given in Annex C, Part C.2.

Table 4-3: Recommended Video Service Data Sizes

VIDEO SERVICE	MULTIPLEXING PARAMETER p, n OR IN CASE OF NO MULTIPLEXING: q = THE NUMBER OF VIDEO DATA OCTETS PER SDU	CPN SERVICE RECOMMENDED	GRADE OF CPN SERVICE
V4 High Resolution Video	q ≤ full B_SDU-size only non-multiplexed video data	Bitstream service	grade 2 or grade 3[1]
V3 Broadcast Resolution Video[2]	q ≤ full B_SDU-size only non-multiplexed video data	Bitstream service	grade 2 or grade 3[1]
V2 Moderate Resolution Video[2]	for non-multiplex: q ≤ full B_SDU-size	Bitstream service	grade 2 or grade 3[1]

	for multiplex:
	if n = 1:
	p ≤ full VCA_SDU-size
	
	if n > 1 (multiplexed):
	p ≤ VCA_SDU-size/n
		VCA service	

V1 Low Resolution Video	for non-multiplex: q ≤ full B_SDU-size	Bitstream service	grade 2 or grade 3[1]

	for multiplex:
	if n = 1:
	p ≤ full VCA_SDU-size
	
	if n > 1 (multiplexed):
	p ≤ VCA_SDU-size/n
		VCA service	

[1] In accordance to the data reliability requirements.
[2] Service identified for early cross support.

5 STILL-IMAGE SERVICES AND MULTIPLEXING SPECIFICATIONS

5.1 STILL-IMAGE SERVICES AND APPLICATIONS

Table 5-1 gives a brief survey of the potential still-image services in the space environment and the related applications and operational aspects.

Table 5-1: List of Still-Image Services and Applications

STILL-IMAGE SERVICE	APPLICATION	OPERATIONAL ASPECTS
I3 Still-Image Mode-3[1]	• Visual and computer-aided exploitation of experiments • adaptable to any spatial picture resolution • data compression with lossy coding, but adjustable reconstruction accuracy (compress. ratio ≥ 3)	• unidirectional link • space ↔ ground • on demand or during scheduled phases (e.g., experiment duration)
I2 Still-Image Mode-2[1]	• Visual and computer-aided exploitation of experiments • adaptable to any spatial picture resolution • data compression with no loss of picture information (compression ratio < 3)	• unidirectional link • space ↔ ground • on demand or during scheduled phases (e.g., experiment duration)
I1 Still-Image Mode-1	• Visual and computer-aided exploitation of experiments • adaptable to any spatial and radiometric picture resolution • no compression • low mass and low power alternative for quantitative use	• unidirectional link • space ↔ ground • on demand or during scheduled phases (e.g., experiment duration)

[1] Service identified for early cross support.

The distinction here between “video” and “still image” (sections 4 and 5, respectively) is the following:

– Video provides continuous visual information about the “real-time” situation (taking transmission delays into account). It is based on an interactive mode of operation (e.g., for “Telescience”), giving a human observer with adequate control capabilities information valid enough to react in “quasi” real time to the situation.

– Still-Image service provides visual and quantitative information about a situation at an identified time. It provides sufficient information and fidelity to be exploited for the interpretation of an experiment and the extraction of scientific results. (In certain cases it may also be used in an interactive mode of operation.)

5.2 STILL-IMAGE SERVICE PERFORMANCE

Table 5-2 provides definitions for the still-image services currently envisaged for space applications (as provided by the CPN).

Table 5-2: Still-Image Services Definitions

STILL-IMAGE SERVICE	SPATIAL AND RADIOMETRIC RESOLUTION	DATA RATE ALLOCATION[1]	COMPRESSION STANDARDS
I3 Still-Image Mode-3[2]	covers the full spatial resolution scale R,G,B or Y,U,V 8 bit/pel/component	depends on the image rate, the spatial image resolution, the image entropy and the compression parameter compression ratio ≥ 3	ISO/IEC CD 10918-1 (JPEG, Baseline)
I2 Still-Image Mode-2[2]	covers the full spatial resolution scale R,G,B or Y,U,V or other spectral image components ≤ 16 bit/pel/component	depends on the image rate, the spatial image resolution, the image entropy and the compression parameter compression ratio < 3	ISO/IEC CD 10918-1 lossless mode (JPEG lossless)
I1 Still-Image Mode-1	covers the full spatial and radiometric resolution scale R,G,B or Y,U,V or other spectral image components	depends on the image rate and the spatial and radiometric image resolution	no compression no standard necessary

[1] Data rate allocation in one direction, point to point.
[2] Service identified for early cross support.

5.3 STILL-IMAGE SERVICE MULTIPLEXING

A still-image data source submits only a determined volume of data per still image to the CPN (if image data compression is used, the image data volume can be variable depending on the image entropy of the input image). Therefore, the data of a still image is given as a block of octets to a CPN access point, which uses an appropriate CPN service to transmit the image.

5.3.1 Recommended CPN Services for Still-Image Communications

Because the packetized data structure of the still-image data has a defined data volume, the "Encapsulation service" and "Path service" can be applied as very efficient CPN services for the still-image data transmission.

Table 5-3 provides a brief list of the recommended CPN Services. The still-image services are defined in terms of: (a) the CPN service type and (b) the CPN Grade of Service.

Table 5-3: Recommended CPN Services for the Still-Image Services

STILL-IMAGE SERVICE	CPN SERVICE RECOMMENDED	GRADE OF CPN SERVICE
I3 Still-Image Mode-3[1]	Path service[2]	grade 2[3]
I2 Still-Image Mode-2[1]	Path service[2]	grade 2[3]
I1 Still-Image Mode-1	Path service[2]	grade 2

[1] Service identified for early cross support.
[2] Start of image data always has to be coincident with the beginning of a Path service data packet.
[3] For compressed image data, only CPN grade 2 is applicable.

ANNEX A

COMPATIBILITY BETWEEN SPACE AUDIO APPLICATIONS AND INTERNATIONAL STANDARDS FOR AUDIO

(THIS ANNEX **IS** PART OF THE RECOMMENDATION)

Purpose:

This annex identifies relevant international audio standards and relates space audio applications to specific international standards. The international standards for audio considered are transmission and coding standards (or, as the case may be, recommendations) defined by CCITT.

A.1 SURVEY OF RELEVANT DOCUMENTS

TOPIC	RECOMMENDATION #
Digital Networks	CCITT G.700
Digital Hierarchy of bit rates	CCITT G.702
Physical and electrical characteristics	CCITT G.703
Functional characteristics of interfaces	CCITT G.704
Pulse Code Modulation of Voice frequencies	CCITT G.711/712/713
ADPCM coding at 32 kbps	CCITT G.721
7 kHz Audio-Coding within 64 kbps	CCITT G.722
Coding of Speech at 16 kbps (Draft)	CCITT G.728[1]
Characteristics of PCM multiplex	CCITT G.73X
at 2.048 Mbps	CCITT G.732
at 64/384 kbps	CCITT G.735/736/737
Error performances and Link quality objectives for 64 kbps voice traffic	CCITT G.821
Coding of sound with 15 kHz bandwidth (stereo)	CCITT J.41
Coding of sound with 7 kHz bandwidth	CCITT J.42
Frame Structure for a 64 to 1920 kbps channel in audiovisual teleservice	CCITT H.221[2]
ISDN	CCITT I.120
Broadband aspects	CCITT I.121
Service capabilities	CCITT I.200
Bearer services	CCITT I.230
Circuit mode bearer services	CCITT I.231
Teleservices	CCITT I.240/241
Protocol reference model	CCITT I.320
User Network interfaces	CCITT I.410/411/412
Multiplexing and rate adaption	CCITT I.460

[1] CCITT G.728 draft recommendation from December 1991.

[2] CCITT H.221 draft revision from May 1992.

A.2 RELATIONSHIP BETWEEN SPACE AUDIO APPLICATIONS AND CODING STANDARDS

APPLICATION EXAMPLE	RECOMMENDATION #
Hi-fi Audio	CCITT J.41
Enhanced Audio	CCITT J.41/42, G.722
Operational Audio	CCITT G.711, G.721
	CCITT G.728[1], G735
	CCITT I.230, I.231
Low Rate Audio	FED-STD-1016 (CELP)[2]
	FED-STD-1015 (LPC-10)[2]
Embedded Audio in Video	CCITT H.221 (draft)[3]

1 CCITT G.728 draft recommendation from December 1991.

2 The FED standard will be replaced by an equivalent CCITT standard when available.

3 CCITT H.221 draft revision from May 1992.

ANNEX B

COMPATIBILITY BETWEEN SPACE VIDEO AND STILL-IMAGE APPLICATIONS AND INTERNATIONAL STANDARDS

(THIS ANNEX **IS** PART OF THE RECOMMENDATION)

Purpose:

This annex identifies relevant international video standards and relates space video applications to specific international standards. The international standards considered here are transmission and coding standards defined by CCITT, CMTT, CCIR and ISO/IEC.

B.1 SURVEY OF RELEVANT DOCUMENTS

TOPIC	RECOMMENDATION #
Visual telephony systems	CCITT H.100
Codec for primary digital group transmission	CCITT H.120
Frame structures	CCITT H.130
Frame structures for a 64 kbps to 1920 kbps in channel in audiovisual teleservices	CCITT H.221[1]
Signaling system for establishing audiovisual communication	CCITT H.242[2]
Codec for audiovisual services at p $*$ 64 kbps	CCITT H.261[3]
ISDN recommendations (I series) also apply.	CCITT I.series
Compression algorithm for still-images	ISO/IEC CD 10918-1
Digital video sampling	CCIR 601
High resolution video	CCIR 709
High resolution video compression	CMTT (proposed)
Compression algorithm for broadcast video (for 30–45 Mbps)	AD/CMTT[4]
Proposed compression algorithm for broadcast video	ISO/MPEG2 (proposed)

[1] CCITT H.221 draft revision from May 1992.

[2] CCITT H.242 draft revision from May 1992.

[3] CCITT H.261 draft revision from May 1992.

[4] AD/CMTT algorithm will be published as CCIR 723 recommendation.

B.2 RELATIONSHIP BETWEEN SPACE VIDEO AND STILL-IMAGE APPLICATIONS AND CODING STANDARDS

APPLICATION EXAMPLE	RECOMMENDATION #
High Resolution video	CCIR 709
	CMTT (proposed)
	MPEG3 (planned 1994)
Broadcast Resolution video	CCIR 601
	AD/CMTT[1]
Moderate Resolution video	CCITT H.261, [H.221]
Still-Image Mode-2	ISO/IEC CD 10198-1
	(lossless)
Still-Image Mode-3	ISO/IEC CD 10198-1 (baseline)

[1] AD/CMTT algorithm will be published as CCIR 723 recommendation.

ANNEX C

OVERVIEW OF AUDIO AND VIDEO DATA TRANSFER USING VCA, INSERT SERVICE, AND BITSTREAM SERVICE, AND THE OPTIONAL AUDIO AND VIDEO TRANSMISSION VIA PATH OR ENCAPSULATION SERVICE

(THIS ANNEX **IS** PART OF THE RECOMMENDATION)

Purpose:

This annex specifies the recommended mechanisms for communicating A/V/SI application data using the underlying CPN communication services.

C.1 RECOMMENDED AUDIO AND VIDEO DATA TRANSMISSION VIA CPN

C.1.1 AUDIO DATA MULTIPLEXING MODEL

The continuous data stream of an audio service transmitted via the CPN is an ordered succession of audio data structures as Audio Data Packages (ADPs) and Audio Data Fields (ADFs). Each ADF is a limited-length, octet-aligned data structure containing "n" Audio Data Blocks (ADBs) as a sub-data structure ("n" equals the number of audio channels which share that Virtual Channel [VC]), which again consists of "p" audio channel data octets. This scheme may be illustrated in simplified terms as in figure C-1.

ADPs can be created out of "m" successive ADFs. The ADP with m > 1 should be used only in special cases (e.g., low data rate over Space Link using the CPN Insert service for audio data transmission). The normal case is m = 1, which means ADF = ADP. It is advised for the audio services to use a separate audio service data stream for each different service supported.

The values of "m", "n" and "p" are constrained by:

a) the type and bit rate of the CPN service;

b) the audio channel data rate;

c) the accepted end-to-end delay of the audio signals.

For multiplexed audio, the Audio Protocol Data Unit (A_PDU) is defined to be an ADP which fits into one VCDU/CVCDU Data Unit Zone.

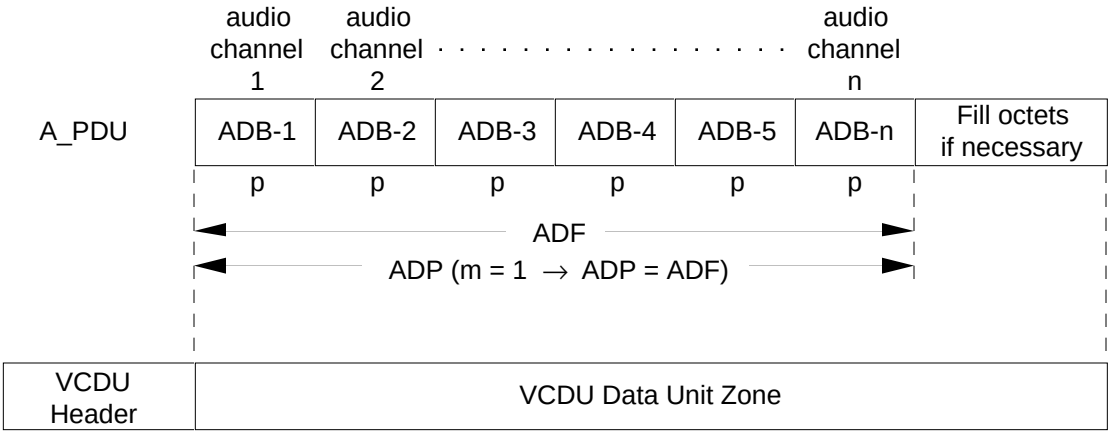

Figure C-1: Audio Data

The values of "m", "n" and "p" are bound by management onto one particular VC (i.e., there is no inline protocol to specify the values).

C.1.2 VIDEO DATA MULTIPLEXING MODEL

The current video-sources/video-codecs deliver a fixed output data rate, so the applied CPN service has to provide a sequence-preserving quasi-isochronous data transmission to get a continuous video data stream on the receiver side.

To achieve a minimal delay at this transmission and/or to provide several video channels within one video service data stream, a multiplexing scheme has to be implemented in analogy to the audio service multiplexing model.

This video multiplexing scheme at level 1 of the end-to-end video transport model (see Figure 2-1) has to be applied

- if a minimal video signal delay is considered;

- if more than one video channel within the video service data stream on one VC (e.g., for an isochronous stereo application) has to be transmitted.

Video service data streams that are not multiplexed (only one video channel per VC) are not covered by this multiplexing model, since the CCSDS VC multiplexing scheme at level 0 will be sufficient.

Video data are assumed to consist of either a stream of bits from one video source (which is transferred using a dedicated VC), or Video Protocol Data Units (V_PDUs) which allow several video sources to share one VC.

No structure or protocol is defined in this proposed Recommendation for the unmultiplexed (bitstream) type of video.

For multiplexed video, the V_PDU is defined to be a Video Data Field (VDF) which fits into one VCDU/CVCDU Data Unit Zone. The VDF contains “n” Video Data Blocks (VDBs) each containing “p” octets of video data (“n” equals the number of video channels which share that VC). The values of “n” and “p” are constrained by:

a) the type and bit rate of the CPN service;

b) the video channel data rate;

c) the accepted end-to-end delay of the video signals.

These options may be illustrated in simplified terms as follows:

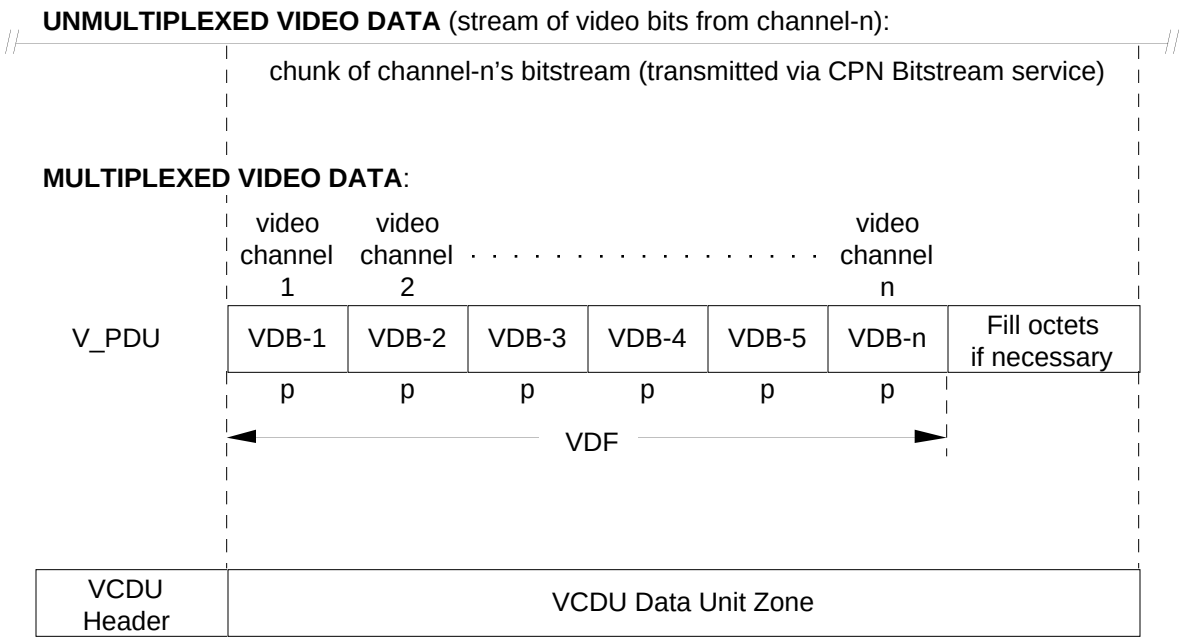

Figure C-2: Video Data

The values of "n" and "p" are bound by management onto one particular VC (i.e, there is no inline protocol to specify the values).

C.2 OPTIONAL AUDIO AND VIDEO DATA TRANSMISSION VIA PATH AND ENCAPSULATION SERVICE[1]

For the audio and video data transfer with fixed data rate, the use of the CPN Path service and Encapsulation service is also allowed. In practical terms, the use of Path and Encapsulation service means that audio, video and other data can be encapsulated within CCSDS Packets during their transfer.

The Path service is an asynchronous and non-sequence-preserving end-to-end service. The Encapsulation service is an asynchronous and sequence-preserving Space Link service.

For video data out of "Packet-Video"[2]-codecs the transfer via the "octet string" option of the CCSDS Path service should be used, if the data has to be transferred at the CPN Network

---

1 Can be used for packet video systems.

2 "Packet-Video"-codecs deliver a variable output data volume per image within the corresponding image/time interval. The amount of data per image has to have an upper limit, which will be chosen for the application by the service user. For a fully redundant image in a video sequence the lower limit of the data volume is only the video framing octets including no real image data. For such "Packet-Video"-codecs only those CPN services are appropriate which can cope with variable-length data packets within a fixed time interval.

layer. Encapsulation service should be used if this data has to traverse only the SLS. Path and Encapsulation service can both cope with the variable-length data packages coming from a “Packet-Video”-codec.

The CCSDS Packet is a low-overhead data structure which consists of a 6-octet Packet Header (PH), an optional Secondary Header, and a variable-length data field. The PH provides an ID field, a sequence count, and a packet-length indicator. These options may be illustrated in simplified terms as in figure C-3.

Within this scheme Data Blocks (DBs) of audio and video would be encapsulated within CCSDS Packets, using CCSDS Path Protocol Data Units (CP_PDUs) at the CPN Network layer or Encapsulation Service Data Units (E_SDUs) if the data traverses only the Space Link Subnet. The Application Process ID (APID) in the CCSDS Packet would identify the channel.

The packages can be of fixed or of variable length both between packages of different video channels and within a packet video channel. This flexibility allows the option of mixing channels of differing rates or of accommodating channels with a time-varying output rate.

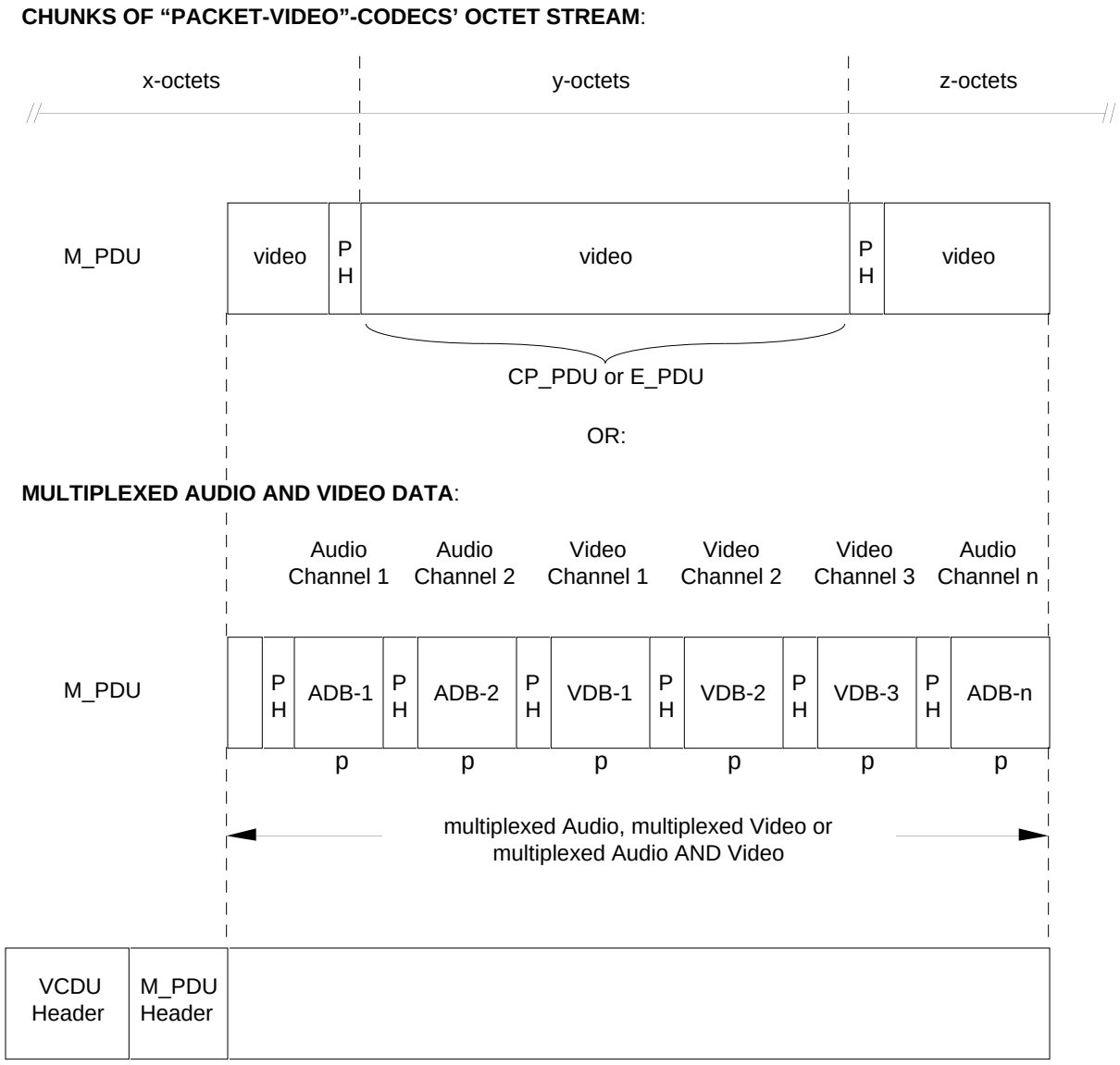

Figure C-3: Optional Packetized Audio and Video Services

ANNEX D

RECOMMENDATIONS FOR INTEROPERABILITY

(THIS ANNEX **IS** PART OF THE RECOMMENDATION)

Purpose:

For audio as well as for video a minimum of a standard-quality service and an enhanced-quality service shall be available. A minimum set of parameters is given for the guidance of the implementer.

Two still-image services are selected in order to serve for scientific images (lossless coding) as well as for visual-quality images for which lossy coding might be applied.

Table D-1: Recommended Interoperability Parameters

#	SERVICE	STANDARD ADOPTED	CPN SERVICE RECOMMENDED	GRADE OF CPN SERVICE
	Audio:			
1	A2; 3.4 kHz; 64 kbps	CCITT G.711	VCA	2 or 3
2	A2; 3.4 kHz; 16 kbps	CCITT G.728	Insert	2
3	A3; 7 kHz; 48 kbps	CCITT G.722	VCA	2
	Video:			
4	V2; 384 kbps[1]	CCITT H.261	VCA (MUXed) or Bitstream (unMUXed)	2[6]
5	V2; 1536 kbps[1]	CCITT H.261	VCA (MUXed) or Bitstream (unMUXed)	2[6]
6	V2; 1920 kbps[1]	CCITT H.261	VCA (MUXed) or Bitstream (unMUXed)	2[6]
7	V3; 34048 kbps[2, 3]	AD/CMTT[5]	Bitstream	2
8	V3; 43904 kbps[2, 4]	AD/CMTT[5]	Bitstream	2
	Still-Image:			
9	I2; (lossless)	CCSDS-P1A	Path	2
10	I3; (lossy)	ISO/IEC CD 10918-1 (=JPEG)	Path	2

1 The data rate allocation of a coder equal to CCITT Rec. H.261 video coding and compression ranges in steps of 64 kbps up to 2048 kbps (p*64 kbps, p=1...32). Preferred data rates are 384 kbps, 1536 kbps, 1920 kbps (including space for CCITT H.221 framing data) if only video data has to be transmitted. If audio and video data in parallel are transmitted via a video channel, the preferred data rate for video only (without H.221 framing data) is either 320 kbps (adapted to one H0-channel), 312 kbps (adapted for an audio/video data transmission via 6 B-channels), 1472 kbps (adapted to one H11-channel), or 1856 kbps (adapted to one H12-channel). The additional audio data + H.221 framing data takes 64 kbps.

2 The AD/CMTT algorithm works with output buffer regulation, so the adaptation to a specific output data rate within the target data range of 30–45 Mbps can be achieved.

3 AD/CMTT overall video bit rate: 34048 kbps, inserted on ground into CCITT G.751 frames. The data stream takes then 34386 kbps (which is part of the European digital hierarchy for ground communication).

4 AD/CMTT overall video bit rate: 43904 kbps, inserted on ground into CCITT G.752 frames. The data stream takes then 44736 kbps (which is part of the US digital hierarchy for ground communication).

5 AD/CMTT algorithm will be published as CCIR 723 recommendation.

6 Using a CPN grade-2 service on downlink the H.261 codecs might not use BCH error-correction coding if no terrestrial link is used for further data transmission.

Table D-2: Other Recommended Interoperability Parameters for Audio

#	SERVICE	OTHER ESSENTIAL PARAMETERS
	Audio	
1	A2; 3.4 kHz; 64 kbps; G.711	audio sample quantization law: A-law; sampling clock stability: < ± 5∗10E-5; end-to-end BER[1]: ≤ 10E-4; VC#; A-Channel#; A-channel MUXing: m, n, p ≤ 400 - 1200
2	A2; 3.4 kHz; 16 kbps; G.728[2]	audio sampling quantization law: A-law; sampling clock stability: < ± 5∗10E-5; end-to-end BER[1]: < 10E-4; VC#; A-Channel#; A-channel MUXing: m, n, p ≤ 100–300
3	A3; 7 kHz; 48 kbps; G.722	uniform quantization according to G.722; sampling clock stability: ≤ ± 5∗10E-5; end-to-end BER[1]: W ≤ 10E-4; G.722, 48 kbps Audio; VC#; A-Channel#; A-channel MUXing: m, n, p

[1] BER = bit error rate (requirement).

[2] Reconstructed audio signal quality (after decompression) is only slightly degraded in comparison to G.711 uncompressed A2-service.

Table D-3: Other Recommended Interoperability Parameters for Video

#	SERVICE	OTHER ESSENTIAL PARAMETERS
	Video:	
4	V2; 384 kbps[1]	CIF, up to 29.97 Hz; VC#; V-Channel#; end-to-end BER[2]: ≤ 10E-8; if V-channel MUXing: n, p; if A/V MUXing: V-coding: 320 kbps Video data; A-coding: G.722, 48 kbps Audio; A-framing: CCITT H.221 BAS[3] = 0x25; (6 B-channels, 5 for video, 1 for Audio)
5	V2; 1536 kbps[1]	CIF, up to 29.97 Hz; VC#; V-Channel#; end-to-end BER[2]: 10E-8; if V-channel MUXing: n, p; if A/V MUXing: V-coding: 1472 kbps Video data; A-coding: G.722, 48 kbps Audio; A-framing: CCITT H.221 BAS[3] = 0x2B; (one 1536 kbps-channel)

[1] The data rate allocation of a coder equal to CCITT Rec. H.261 video coding and compression ranges in steps of 64 kbps up to 2048 kbps (p∗64 kbps, p=1...32). Preferred data rates are 384 kbps, 1536 kbps, 1920 kbps (including space for CCITT H.221 framing data) if only video data has to be transmitted. If audio and video data in parallel are transmitted via a video channel, the preferred data rate for video only (without H.221 framing data) is either 320 kbps (adapted to one H0-channel), 312 kbps (adapted for an audio/video data transmission via 6 B-channels), 1472 kbps (adapted to one H11-channel), or 1856 kbps (adapted to one H12-channel). The additional audio data + H.221 framing data takes 64 kbps.

[2] BER = bit error rate (requirement).

[3] BAS = bit-rate allocation signal (ref: H.221 draft revision May 1992).

Table D-3: Other Recommended Interoperability Parameters for Video (continued)

#	SERVICE	OTHER ESSENTIAL PARAMETERS
6	V2; 1920 kbps[1]	CIF, up to 29.97 Hz; VC#; V-Channel# ; end-to-end BER[2]: ≤ 10E-8; if V-channel MUXing: n, p; if A/V MUXing: V-coding: 1856 kbps Video data; A-coding: G.722, 48 kbps Audio; A-framing: CCITT H.221 BAS[3]= 0x2C; (one 1920 kbps-channel)
7	V3; 34048 kbps[4]	625 lines/25 Hz, CCIR 601, AD/CMTT[5] end-to-end BER[2] ≤ 10E-5 (with AD/CMTT FEC[6]); end-to-end BER[2] ≤ 10E-8 (without FEC[6]); if A/V MUXing: audio channel A, AD/CMTT service MUX structure;
8	V3; 43904 kbps[4]	525 lines/29.97 Hz, CCIR 601, AD/CMTT[5] end-to-end BER[2] ≤ 10E-5 (with AD/CMTT FEC[6]); end-to-end BER[2] ≤ 10E-8 (without FEC[6]); if A/V MUXing: audio channel A, AD/CMTT service MUX structure;

1 The data rate allocation of a coder equal to CCITT Rec. H.261 video coding and compression ranges in steps of 64 kbps up to 2048 kbps (p*64 kbps, p=1...32). Preferred data rates are 384 kbps, 1536 kbps, and 1920 kbps (including space for CCITT H.221 framing data) if only video data has to be transmitted. If audio and video data in parallel are transmitted via a video channel, the preferred data rate for video only (without H.221 framing data) is either 320 kbps (adapted to one H0-channel), 312 kbps (adapted for an audio/video data transmission via 6 B-channels), 1472 kbps (adapted to one H11-channel), or 1856 kbps (adapted to one H12-channel). The additional audio data + H.221 framing data takes 64 kbps.

2 BER = bit error rate (requirement).

3 BAS = bit-rate allocation signal (ref: H.221 draft revision May 1992).

4 The AD/CMTT algorithm works with output buffer regulation, so the adaptation to a specific output data rate within the target data range of 30–45 Mbps can be achieved.

5 AD/CMTT algorithm will be published as CCIR 723 recommendation.

6 FEC = forward error correction.

Table D-4: Other Recommended Interoperability Parameters for Still Image

#	SERVICE	OTHER ESSENTIAL PARAMETERS	
	Still Image:		
9	I2; (lossless)	mode:	Lossless sequential, Huffmann coding
		data format:	interchange format Restart-marker optional
		component sequence:	non-interleaved color components
		component sampling:	4:2:2, 2–16 bit/pel (CCIR 601);
		spatial resolution:	CCIR 601 (720∗576/480)
		end-to-end BER[1]:	≤ 10E-8
10	I3; (lossy)	mode:	Baseline sequential DCT, Huffmann coding
		data format:	interchange format Restart-marker optional
		component sequence:	non-interleaved color components
		component sampling:	4:2:2, 8 bit/pel (CCIR 601);
		spatial resolution:	CCIR 601 (720∗565/480)
		end-to-end BER[1]:	≤ 10E-8

[1] BER = bit error rate (requirement).

ANNEX E

ACRONYMS AND ABBREVIATIONS

(THIS ANNEX **IS NOT** PART OF THE RECOMMENDATION)

Purpose:

This Annex defines acronyms and abbreviations used throughout the Recommendation.

Term	Definition
A/V/SI	Audio, Video, and Still-Image
ADB	Audio Data Block
ADF	Audio Data Field
ADP	Audio Data Package
ADPCM	adaptive differential pulse code modulation
AOS	Advanced Orbiting Systems
APID	Application Process ID
A_PDU	Audio Protocol Data Unit
BAS	bit rate allocation signal
BCH	Bose-Chaudhuri-Hocquenghem (block code)
BER	bit error rate
B_SDU	Bitstream Service Data Unit
CCIR	International Radio Consultative Committee
CCITT	International Telegraph and Telephone Consultative Committee
CCSDS	Consultative Committee for Space Data Systems
CELP	code excited linear prediction
CMTT	Commission Mixte CCITT-CCIR pour les Transmissions Televisuelles et Sonores (joint CCITT-CCIR Commission for transmission of television and sound)
codec	coder/decoder pair
comp.	compressed
CPN	CCSDS Principal Network
CP_PDU	CCSDS path protocol data unit
CVCDU	Coded Virtual Channel Data Unit
DB	data block
DCT	discrete cosine transformation
EIA	Electronic Industries Association
E_SDU	Encapsulation Service Data Unit
FEC	forward error correction
Gbps	gigabits per second
IEC	International Electrotechnical Commission
ISDN	Integrated Services Digital Network

IN_SDU	Insert Service Data Unit
JPEG	Joint Photographic Experts Group
kbps	kilobits per second
kHz	kiloHertz
LPC	linear predictive coding
Mbit	megabit
Mbps	megabits per second
min	minimum
MPEG	Moving Picture Experts Group
MUX	multiplex
PCM	pulse code modulation
pel	picture element
PH	packet header
QCIF	quarter common intermediate format
SDU	Service Data Unit
SLS	Space Link Subnetwork
uncomp.	uncompressed
VC	Virtual Channel
VCA	Virtual Channel Access
VCA_SDU	Virtual Channel Access Service Data Unit
VCDU	Virtual Channel Data Unit
VDB	Video Data Block
VDF	Video Data Field
V_PDU	Video Protocol Data Unit